



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>5</sup> :</b> C10M 133/02, 141/06 // (C10M 141/06 C10M 129/76, 133/16) (C10M 133/02 C10M 133/08, 133/16) C10N 30/06, 40/25	<b>A1</b>	<b>(11) International Publication Number:</b> WO 92/02602  <b>(43) International Publication Date:</b> 20 February 1992 (20.02.92)
<b>(21) International Application Number:</b> PCT/US91/05392 <b>(22) International Filing Date:</b> 30 July 1991 (30.07.91)  <b>(30) Priority data:</b> 560,839 31 July 1990 (31.07.90) US  <b>(71) Applicant:</b> EXXON CHEMICAL PATENTS INC. [US/ US]; 1900 East Linden Avenue, Linden, NJ 07036 (US).  <b>(72) Inventors:</b> YONETO, Yasuhiko ; 309-4, Watauchi, Fujisa- wa City, Kanagawa, Prefecture (JP). BLOCH, Ricardo, Alfredo ; 1532 Ashbrook Drive, Scotch Plains, NJ 07076 (US). RYER, Jack ; 61 Jensen Street, East Brunswick, NJ 08816 (US). BACHMAN, Harold, Erich ; 47 Woodland Drive (Apt. 208), Summit, NJ 07901 (US). SHAUB, Ha- rold ; 45 Ridge Drive, Berkeley Heights, NJ 07922 (US).	<b>(74) Agent:</b> MURRAY, Jack, B., Jr.; Exxon Chemical Com- pany, P.O. Box 710, Linden, NJ 07036 (US).  <b>(81) Designated States:</b> AT (European patent), BE (European patent), CA, CH (European patent), DE (European pa- tent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (Euro- pean patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the</i> <i>claims and to be republished in the event of the receipt of</i> <i>amendments.</i>	
<b>(54) Title:</b> SYNERGYSTIC BLEND OF AMINE/AMIDE AND ESTER/ALCOHOL FRICTION MODIFYING AGENTS FOR IMPROVED FUEL ECONOMY OF AN INTERNAL COMBUSTION ENGINE  <b>(57) Abstract</b>  The fuel economy of an internal combustion engine can be improved by adding to the lubricating oil used to lubricate the crankcase of said engine a synergistic blend of amine/amide and ester/alcohol friction modifying agents.		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU <sup>+</sup>	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TC	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark				

<sup>+</sup> It is not yet known for which States of the former Soviet Union any designation of the Soviet Union has effect.

SYNERGISTIC BLEND OF AMINE/AMIDE AND ESTER/ALCOHOL FRICTION MODIFYING  
AGENTS FOR IMPROVED FUEL ECONOMY OF AN INTERNAL COMBUSTION ENGINE

Background of the invention

Field of the invention

This invention relates to a method for improving the fuel economy of an internal combustion engine, and to a synergistic blend of friction modifiers which may be added to the crankcase lubricating oil of an internal combustion engine for accomplishing such result. The synergistic blend of friction modifiers comprises the combination of (a) an amine/amide friction modifier formed, for example, by reacting a carboxylic acid, such as oleic acid and/or isostearic acid with an amine, such as diethylene triamine or tetraethylene pentamine, and (b) an ester/alcohol friction modifier such as glycerine monooleate and/or glycerine monoricinoleate. The enhanced friction reduction achieved by the use of the synergistic blend of friction modifiers allows the formulation of engine lubricants which meet Tier II fuel economy.

DISCUSSION ON THE PRIOR ART

The constant threat of diminishing sources of fossil fuels and the resulting increases in prices for such fuels, coupled with the federally mandated requirements for reducing the amount of toxic emissions spewed into the atmosphere, has resulted in a great deal of interest in improving fuel economy, particularly the fuel economy of automobile combustion engines.

Such interest has lead to the discovery of cleaner burning compositions, as well as to the discovery of a variety of fuel and/or engine lubricating oil compositions which result in improved fuel economy, that is a higher number of miles obtained in a given vehicle per gallon of fuel.

One such discovery, which is described in U.S.

patent 4,584,112, involves lubricating the crankcase of an internal combustion engine with a lubricating oil composition consisting essentially of a hydrocarbon oil of lubricating viscosity, from 15 to 25 millimoles per kilogram of zinc 0,0-di(2-ethylhexyl) phosphorodithioate, and from 0.25 to 2 wt. % of pentaerythritol monooleate.

U.S. patents 4,492,640 and 4,492,642 also describe methods for reducing the fuel consumption in internal combustion systems. Both of these patents described the addition to lubricating and/or fuel compositions used in an internal combustion engine of a friction reducing compound. The friction reducing compound disclosed in U.S. patent 4,492,640 comprises a boron derivative of a mixture of alkoxyated alcohols and hydroxy sulfides, whereas the friction reducing compound disclosed in U.S. patent 4,492,642 comprises the product formed by reacting a borating agent with an ammoniated hydrocarbyl epoxide.

U.S. patent 4,512,903 discloses lubricating compositions which contain still other friction reducing compounds, namely, amides prepared from mono- or polyhydroxy-substituted aliphatic monocarboxylic acids and primary or secondary amines.

The use of a lubricating oil composition comprising a base oil and a friction modifier in an automatic transmission or a continuously variable transmission, or as a lubricating oil for use in parts including wet clutches or a wet brake of an agricultural tractor is described in European Application 286,996. The friction modifying compounds used in the lubricating oil compositions of that European application are said to include such friction modifiers as phosphoric acid esters, phosphorus acid esters, amine salts of phosphoric acid esters, amine salts of phosphorus acid esters, sorbitan fatty acid esters, pentaerythritol fatty acid esters, glycerine fatty acid esters, trimethylolpropane fatty acid

esters, glycol fatty acid esters, carboxylic acids, carboxylic acid amides, carboxylic acid esters, metal salts of carboxylic acids, fats and oils, higher alcohols and sulfur-containing compounds. The numerous disclosed friction modifiers can be used alone or in combination with one another. This European application states that the lubricating oil compositions exhibit excellent frictional characteristics, which change little with time and which are characterized by excellent stability against oxidation. However, there is no suggestion of using the disclosed lubricating oil compositions as a crankcase lubricant, nor is there any discussion of any possible effect on fuel economy.

A similar disclosure is contained in Japanese Kokai 60-173097. This Japanese publication discloses lubricating oil compositions which are useful in automatic transmissions and which comprise a base oil and a friction modifier. The lubricating oil compositions exhibit high stability against oxidation and change of properties with time, exhibit low shift shock and high transmission torque, and anticorrosive qualities. The friction modifiers which are disclosed in the Japanese publication this document include phosphoric acid esters, phosphorus acid esters or an amine salt thereof; a fatty acid ester of sorbitan, pentaerythritol, glycerine, trimethylolpropane or a glycol; a carboxylic acid or an amide, ester or metal salt thereof; and fats or oils, higher alcohols or sulfur-containing compounds. There is no discussion in the Japanese publication of the possibility of adding the lubricating oil compositions to a crankcase of an internal combustion engine, nor is there any discussion of fuel economy.

#### DESCRIPTION OF THE DRAWING

Figure 1 is a graphical representation of percent

**SUBSTITUTE SHEET**

change in efficiency obtained using an Energy Conserving oil or an Energy Conserving II oil as compared to using a reference HR oil.

#### SUMMARY OF THE INVENTION

It now has been found that if 0.01 to about 2.0 wt. % of an amine/amide, such as the reaction product of a fatty acid (e.g., isostearic acid) and tetraethylene pentamine in combination with about 0.01 to about 2.0 wt. % of an ester/alcohol, such as glycerine monooleate, is added to an otherwise standard lubricating oil composition that is used to lubricate the crankcase of an internal combustion engine, a measurable improvement in fuel economy is accomplished.

Thus, in accordance with the invention, there is provided a crankcase lubricating oil composition comprising an oil of lubricating viscosity and a synergistic blend of at least one compound (A) prepared by reacting an acid or a mixture of acids with a polyamine and at least one compound (B) prepared by reacting an acid or a mixture of acids with a polyol.

The invention also provides a lubricant additive concentrate comprising a lubricant oil and a synergistic blend of amine/amide and ester/alcohol friction modifying agents. It is further contemplated that the synergistic blend of friction modifying agents will aid in the reduction of fuel consumption in an internal combustion engine. Accordingly, the invention provides a method of improving the fuel economy of an internal engine which comprises adding to the crankcase of such engine a lubricant composition containing the herein described synergistic blend of friction modifying agents.

#### DESCRIPTION OF SPECIFIC EMBODIMENTS

As has been mentioned above, the synergistic

**SUBSTITUTE SHEET**

blend of friction modifying agents in accordance with the invention comprises (A) an amine/amide friction modifier and (B) an ester/alcohol friction modifier.

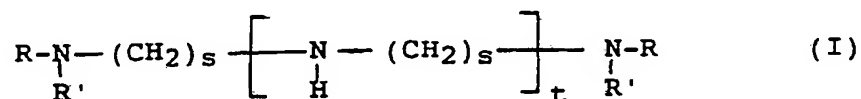
The amine/amide friction modifier can be prepared by reacting an acid or a mixture of acids with a polyamine or mixture thereof. The acids which are suitable for reaction with the polyamine include fatty acids having from about 6 to about 36 total carbon atoms, typically from about 7 to about 24 carbon atoms, and preferably from about 14 to about 20 carbon atoms. The acids may be linear or branched, and may be saturated or unsaturated. Dimer acids such as linoleic acid dimer are also useful.

Non-limiting examples of suitable acids for reaction with the polyamine include: butyric acid, isovaleric acid, caproic acid, heptanoic acid, 2-ethyl hexanoic acid, caprylic acid, pelargonic acid, capric acid, lauric acid, myristic acid, palmitic acid, eicosenic acid, stearic acid, isostearic acid, oleic acid, linoleic acid, ricinoleic acid, behenic acid, erucic acid, behenolic acid, linoleic acid dimer, coconut oil fatty acid, palm kernel oil fatty acid, tall oil fatty acid, and the like, and mixtures thereof. The preferred acid or mixture of acids should have an average from about 7 to about 24, and more preferably from about 14 to about 20, total carbon atoms.

The use of hydroxy fatty acids, such as ricinoleic acid, has been found to be particularly preferred. While the reasons for the exceptional performance characteristics that have been achieved when using a hydroxy fatty acid in preparing the amine/amide and ester/alcohol friction modifiers of the present invention is not completely understood, it is believed that by virtue of one or more hydroxy groups along the carbon chain of the hydroxy fatty acid portion of the friction modifier, there is better cohesion between adjacent molecules of the friction

modifiers and, thus, more effective boundary lubrication.

The amines which are useful for reaction with the above acids to form the amine/amide friction modifiers include polyamines or mixtures of polyamines. Typically, the polyamines will have from about 2 to about 60, and preferably from 3 to about 10, total carbon atoms in the molecule. The useful amines generally will contain from about 2 to about 20 total nitrogen atoms, typically from about 2 to about 14, and preferably from 2 to about 12 nitrogen atoms per molecule. These amines may be hydrocarbyl amines or may be hydrocarbyl amines including other non-interfering groups, e.g., alkoxy groups, amide groups, nitrile groups, imidazoline groups, and the like. Preferred amines are aliphatic saturated amines, including those of the general formula:



wherein R and R' are independently selected from the group consisting of hydrogen; C<sub>1</sub> to C<sub>25</sub> straight or branched chain alkyl radicals; C<sub>1</sub> to C<sub>12</sub> alkoxy C<sub>2</sub> to C<sub>6</sub> alkylene radicals; and C<sub>1</sub> to C<sub>12</sub> alkylamino C<sub>2</sub> to C<sub>6</sub> alkylene radicals; each s is the same or a different number of from 2 to 6, preferably 2 to 4; and t is a number of from 0 to 10, preferably 2 to 7. If t=0, then at least one of R or R' must be H such that there are at least two of either primary or secondary amino groups.

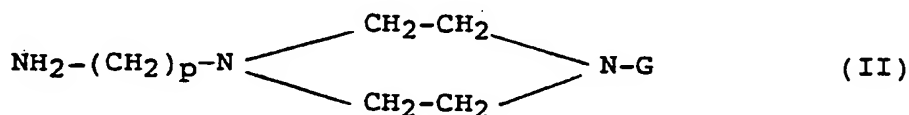
Non-limiting examples of suitable amine compounds include: 1,2-diaminoethane; 1,3-diaminopropane; 1,4-diaminobutane; 1,6-diaminohexane; polyethylene amines such as diethylene triamine; triethylene tetramine; tetraethylene pentamine; polypropylene amines such as 1,2-propylene diamine; di-(1,2-propylene) triamine; di-(1,3-propylene) triamine; N,N-dimethyl-1,3-diamino-

**SUBSTITUTE SHEET**



propane; N,N-di-(2-aminoethyl) ethylene diamine; N-dodecyl-1,3-propane diamine; di-, and tri-tallow amines; amino morpholines such as N-(3-aminopropyl) morpholine; etc.

Other useful amine compounds include: alicyclic diamines such as 1,4-di(aminomethyl) cyclohexane, and heterocyclic compounds such as morpholines, imidazolines, and N-aminolakyl piperazines of the general formula:



wherein G is independently selected from the group consisting of hydrogen and omega-(non-tertiary)aminoalkylene radicals of from 1 to 3 carbon atoms, and p is a number of from 1 to 4. Non-limiting examples of such amines include 2-pentadecyl imidazoline; N-(2-aminoethyl) piperazine; etc.

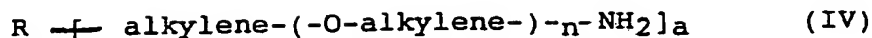
Commercial mixtures of amine compounds advantageously may be used. For example, one process for preparing alkylene amines involves the reaction of an alkylene dihalide (such as ethylene dichloride or propylene dichloride) with ammonia, which results in a complex mixture of alkylene amines wherein pairs of nitrogens are joined by alkylene groups, forming such compounds as diethylene triamine, triethylenetetramine, tetraethylene pentamine and isomeric piperazines. A low cost mixture of poly(ethyleneamines) compounds averaging about 5 to 7 nitrogen atoms per molecule are available commercially under trade names such as "Polyamine H", "Polyamine 400", "Dow Polyamine E-100", etc.

Useful amines also include polyoxalkylene polyamines such as those of the formulas:



**SUBSTITUTE SHEET**

where m has a value of about 3 to 70 and preferably 10 to 35; and



where n has a value of about 1 to 40 with the proviso that the sum of all the n's is from about 3 to about 70 and preferably from about 6 to about 35, R is a polyvalent saturated hydrocarbon radical of up to ten carbon atoms, and a is a number from 3 to 6. The alkylene groups in either formula III or IV may be straight or branched chain containing about 2 to 7, and preferably about 2 to 4 carbon atoms.

The above polyoxyalkylene polyamines, preferably polyoxyalkylene diamines and polyoxyalkylene triamines, may have average molecular weights ranging from about 200 to about 4,000 and preferably from about 400 to about 2,000. The preferred polyoxyalkylene polyamines include the polyoxyethylene and polyoxypropylene diamines and the polyoxypropylene triamines having average molecular weight ranging from about 200 to 2,000. The polyoxyalkylene polyamines are commercially available and may be obtained, for example, from the Jefferson Chemical Company, Inc. under the trade name "Jeffamines D-230, D-400, D-1000, D-2000, T-403", etc.

Still other useful amines are those which can be generalized by the formula



where Z may be  $-\text{CH}_2\text{CH}_2\text{CH}_2-(\text{CH}_2\text{CH}_2\text{CH}_2\text{NH})_n\text{CH}_2\text{CH}_2\text{CH}_2-$ , where n is 1-6, or  $-(\text{CH}_2\text{CH}_2\text{CH}_2\text{NH})_m\text{CH}_2(\text{CH}_2)_p(\text{NH}-\text{CH}_2\text{CH}_2\text{CH}_2)_m-$ , where m and m' are each at least 1 and m + m' is 2-5, p is 1-4 and a is a number from 1-20.

Further amines include polyamino propyl amines having C-substituents such as C<sub>12</sub>-C<sub>20</sub> alkyl, C<sub>6</sub>-C<sub>10</sub>

aryl, hydroxyl, thiol, cyano, ethoxy, polyoxyethylene and polyoxypropylene having a degree of polymerization of 2-10 and other compatible non-reactive functional groups, but N-substituted polyamines are not suitable reactants in preparing macrocyclic compounds in a cyclodehydration reaction, i.e. the nitrogen atoms must be either -NH or -NH<sub>2</sub>. Preferably Z is -CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-, -(CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH)<sub>n</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>- where n is 1-3, or -(CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH)<sub>m</sub>(CH<sub>2</sub>CH<sub>2</sub>)(NHCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>)<sub>m'</sub>-, where m and m' are as described above.

The amine is readily reacted with the acid material, e.g. oleic acid by heating an oil solution containing 10 to 95 wt. % of acid material to about 160 to 200°C., preferably 180 to 190°C., generally for 2 to 6, e.g. 3 to 5 hours until the desired amount of water is removed.

While the amine may be used in any amount effective to form an amide from the acid material, generally the amine and acid are contacted in an acid amine equivalent ratio of from about 1:10 to 1:1, preferably from about 1:4 to 2:3.

The ester/alcohol friction modifiers may be prepared by reacting an acid or mixture of acids with a polyol or mixture thereof. The acids suitable for use include those acids described hereinabove.

The polyols contemplated for use in this invention include aliphatic polyhydric alcohols containing up to about 100 carbon atoms and about 2 to about 10 hydroxyl groups. These alcohols can be quite diverse in structure and chemical composition, for example, they can be substituted or unsubstituted, hindered or unhindered, branched chain or straight chain, etc. as desired. Typical alcohols are alkylene glycols such as ethylene glycol, propylene glycol, trimethylene glycol, butylene glycol, and polyglycol such as diethylene glycol, triethylene glycol, tetraethylene glycol, dipropylene glycol, tripropylene glycol, dibutylene glycol, tributylene glycol, and

SUBSTITUTE SHEET

other alkylene glycols and polyalkylene glycols in which the alkylene radical contains from two to about eight carbon atoms. Other useful polyhydric alcohols include glycerol, monomethyl ether of glycerol, pentaerythritol, dipentaerythritol, tripentaerythritol, 9,10-dihydroxystearic acid, the ethyl ester of 9,10-dihydroxystearic acid, 3-chloro-1, 2-propanediol, 1,2 butanediol, 1,4-butanediol, 2,3-hexanediol, 2,3-hexanediol, pinacol, tetrahydroxy pentane, erythritol, arabitol, sorbitol, mannitol, 1,2-cyclohexanediol, 1,4-cyclohexanediol, 1,4-(2-hydroxyethyl)-cyclohexane, 1,4-dihydroxy-2-nitro-butane, 1,4-di-(2-hydroxyethyl)-benzene, the carbohydrates such as glucose, rhamnose, mannose, glyceraldehyde, and galactose, and the like, amino alcohols such as di(2-hydroxyethyl)amine, tri-(3-hydroxypropyl)amine, N,N'-di-(hydroxyethyl)-ethylenediamine, copolymer of allyl alcohol and styrene, N,N-di-(2-hydroxyethyl) glycine and esters thereof with lower mono-and polyhydric aliphatic alcohols etc.

Included within the group of aliphatic alcohols are those alkane polyols which contain ether groups such as polyethylene oxide repeating units, as well as those polyhydric alcohols containing at least three hydroxyl groups, at least one of which has been esterified with a mono-carboxylic acid having from eight to about 30 carbon atoms such as octanoic acid, oleic acid, stearic acid, linoleic acid, dodecanoic acid, or tall oil acid, Examples of such partially esterified polyhydric alcohols are the mono-oleate of sorbitol, the mono-oleate of glycerol, the mono-stearate of glycerol, the di-stearate of sorbitol, and the di-dodecanoate of erythritol.

Also included among the alcohols which may be used in the invention are containing nitrogen or sulfur such as the thiobisethanols and amino-alcohols.

Useful amino alcohol compounds include 2,2-disubstituted-2-amino-1-alkanols having from two to

three hydroxyl group sand containing a total of 4 to 8 carbon atoms. This amino alcohol can be represented by the formula:



wherein X is an alkyl or hydroxyalkyl group with the alkyl groups having from 1 to 3 carbon atoms wherein at least one, and preferably both, of the X substituents is a hydroxyalkyl group of the structure  $(\text{CH}_2)_n\text{OH}$ , n being 1 to 3, Examples of such amino alcohols include: 2-amino-2-methyl-1,3 propanediol; 2-amino-2-ethyl-1,3-propanediol; and 2-amino-2-(hydroxymethyl)-1,3-propanediol, the latter also being known as THAM, or tris (hydroxymethyl) amino methane. THAM is particularly preferred because of its effectiveness, availability and low costs.

A preferred class of ester intermediates are those prepared from aliphatic alcohols containing up to 20 carbon atoms, and especially those containing three to 15 carbon atoms. This class of alcohols includes glycerol, erythritol, pentaerythritol, dipentaerythritol, tripentaerythritol, gluconic acid, glyceraldehyde, glucose, arabinose, 1,7-heptanediol, 2,4-heptanediol, 1,2,3-hexanetriol, 1,2,4-hexanetriol, 1,2,5-hexanetriol, 2,3,4-hexanetriol, 1,2,3-butanetriol, 1,2,4-butanetriol, quinic acid, 2,2,6,6-tetrakis(hydroxymethyl)-cyclohexanol, 1,10-decanediol, digitalose, and the like. The esters prepared from aliphatic alcohols containing at least three hydroxyl groups and up to fifteen carbon atoms are particularly preferred.

An especially preferred class of polyhydric alcohols for preparing the ester/alcohol friction reducing agents used in the present invention are the polyhydric alkanols containing 3 to 15, especially 3 to 6 carbon atoms and having at least 3 hydroxyl groups.

Such alcohols are exemplified in the above specifically identified alcohols and are represented by glycerol, erythritol, pentaerythritol, mannitol, sorbitol, 1,2,4-hexanetriol, and tetrahydroxy pentane and the like.

The polyol component is readily reacted with the acid component, e.g. ricinoleic acid or oleic acid, by heating a mixture of the polyol and acid in a reaction vessel in the absence of a solvent at a temperature of about 130°C to about 180°C, typically about 140°C to about 160°C, and preferably at about 145°C to about 150°C, for a sufficient period of time to effect reaction, typically from about 4 to about 6 hours. Optionally, a solvent for the acid, polyol and/or the resulting ester/alcohol product may be employed to control viscosity and/or the reaction rates.

The acids that are suitable for reaction with the polyol component to prepare the ester/alcohol products that are usable in the present invention are the same acids that have been described above in connection with the amine/amide friction modifiers.

In one preferred embodiment of the invention, the acid, e.g. oleic and or more preferably, a hydroxy acid such as ricinoleic acid, is reacted with a polyol, e.g., glycerol, in a 2:1 mole ratio of acid to glycerol. In practice, the ratio of acid to polyol may vary. For example, the mole ratio of acid to polyol may vary from about 3:1 to about 1:1. As is the case with the acid/polyamine adducts, it is necessary to maintain an excess of acid in the reaction mixture on a molar basis.

#### THE COMPOSITIONS

The amine/amide and ester/alcohol friction modifier blend of the present invention, when added to an oil of lubricating viscosity, have been found to impart exceptionally good friction reduction properties, as measured in terms of fuel economy of

internal combustion engines having had their crankcases lubricated with such oil compositions.

Accordingly, the synergistic blends of friction modifiers contemplated by this invention are used by incorporation and dissolution into an oleaginous material such as internal engine crankcase lubricating oil formulations which employ a base oil in which the various additives are dissolved or dispersed.

Base oils suitable for use in preparing lubricating compositions of the present invention include those conventionally employed as crankcase lubricating oils for spark-ignited and compression-ignited internal combustion engines, such as automobile and truck engines, marine and railroad diesel engines, and the like. Such base oils may be natural or synthetic although the natural base oils will derive a greater benefit.

Thus, the synergistic blend of additives of the present invention suitably may be incorporated into synthetic base oils such as alkyl esters of dicarboxylic acids, polyglycols and alcohols, polyalphaolefins, alkyl benzenes, organic esters of phosphoric acids, polysilicone oils, etc.

Natural base oils include mineral lubricating oils which may vary widely as to their crude source, e.g., whether paraffinic, naphthenic, mixed, paraffinic-naphthenic, and the like; as well as to their formation, e.g., distillation range, straight run or cracked, hydrofined, solvent extracted and the like.

More specifically, the natural lubricating oil base stocks which can be used in the compositions of this invention may be straight mineral lubricating oil or distillates derived from paraffinic, naphthenic, asphaltic, or mixed base crudes, or, if desired, various blends oils may be employed as well as residuals, particularly those from which asphaltic constituents have been removed. The oils may be refined by conventional methods using acid, alkali,

and/or clay or other agents such as aluminum chloride, or they may be extracted oils produced, for example, by solvent extraction with solvents of the type of phenol, sulfur dioxide, furfural, dichlorodiethyl ether, nitrobenzene, crotonaldehyde, molecular sieves, etc.

The lubricating oil base stock conveniently has a viscosity of typically about 2.5 to about 12, and preferably about 2.5 to about 9 cs. at 100°C.

Thus, the herein contemplated blend of friction modifying agents can be employed in a lubricating oil composition which comprises lubricating oil, typically in a major amount, i.e., greater than 50 wt.%, and the blend of friction modifiers, typically in a minor amount, i.e., less than 50 wt.%, which is effective to impart unexpectedly enhanced friction reduction properties, relative to the absence of the subject friction modifying additives. Additional conventional additives selected to meet the particular requirements of a selected type of lubricating oil composition can be included as desired.

The friction modifying additives of this invention are oil-soluble, dissolvable in oil with the aid of a suitable solvent, or are stably dispersible in oils. Oil-soluble, dissolvable, or stably dispersible as that terminology is used herein does not necessarily indicate that the materials are soluble, dissolvable, miscible, or capable of being suspended in oil in all proportions. It does mean, however, that the friction modifying additives, for instance, are soluble or stably dispersible in oil to an extent sufficient to exert their intended effect in the environment in which the oil is employed. Moreover, the additional incorporation of other additives may also permit incorporation of higher levels of a particular friction modifier, if desired.

Accordingly, while any effective amount of the amine/amide and ester/alcohol friction modifier

**SUBSTITUTE SHEET**



additives can be incorporated into the lubricating oil composition, it is contemplated that such effective amount be sufficient to provide said lube oil composition with an amount of the amine/amide friction modifier additive of typically from about 0.01 to about 2, and preferably from about 0.2 to about 0.5 wt.%, based on the weight of said composition, and with an amount of ester/alcohol friction modifier additive typically from about 0.01 to 2, and preferably from about 0.2 to about 0.5 wt.%. It is also contemplated that the weight ratio of the amine/amide friction modifier to the ester/alcohol friction modifier typically will be from about 1:10 to 10:1, and preferably from about 1:2 to 2:1.

The friction modifier additives of the present invention can be incorporated into the lubricating oil in any convenient way. Thus, they can be added directly to the oil by dispersing, or dissolving the same in the oil at the desired level of concentration typically with the aid of a suitable solvent such as toluene, or tetrahydrofuran. Such blending can occur at room temperature or elevated temperatures. Alternatively, the friction modifier additives may be blended with a suitable oil-soluble solvent and base oil to form a concentrate, and then blending the concentrate with lubricating oil base stock to obtain the final formulation. Concentrates will typically contain from about 20 to about 80 wt.%, and preferably about 20 to about 60 wt.%, by weight of the blended friction modifier additives, and typically from about 80 to about 20%, preferably from about 60 to about 20% by weight base oil, based on the concentrate weight.

The lubricating oil base stock for the friction modifier additive blend of the present invention typically is adapted to perform a selected function by the incorporation of additives therein to form lubricating oil compositions (i.e., formulations).

Representative additives typically present in

such formulations include dispersants, viscosity modifiers, corrosion inhibitors, oxidation inhibitors, other friction modifiers, anti-foaming agents, anti-wear agents, pour point depressants and the like.

Viscosity modifiers impart high and low temperature operability to the lubricating oil and permit it to remain shear stable at elevated temperatures and also exhibit acceptable viscosity or fluidity at low temperatures.

Viscosity modifiers are generally high molecular weight hydrocarbon polymers including polyesters. The viscosity modifiers may also be derivatized to include other properties or functions, such as the addition of dispersancy properties.

These oil soluble viscosity modifying polymers will generally have number average molecular weights of from  $10^3$  to  $10^6$ , preferably  $10^4$  to  $10^6$ , e.g., 20,000 to 250,000, as determined by gel permeation chromatography or membrane osmometry.

Representative examples of suitable viscosity modifiers are any of the types known to the art including polyisobutylene, copolymers of ethylene and propylene, polymethacrylates, methacrylate copolymers, copolymers of an unsaturated dicarboxylic acid and vinyl compound and interpolymers of styrene and acrylic esters.

Corrosion inhibitors, also known as anti-corrosive agents, reduce the degradation of the metallic parts contacted by the lubricating oil composition. Illustrative of corrosion inhibitors are zinc dialkyldithiophosphate, phosphosulfurized hydrocarbons and the products obtained by reaction of a phosphosulfurized hydrocarbon with an alkaline earth metal oxide or hydroxide, preferably in the presence of an alkylated phenol or of an alkylphenol thioester, and also preferably in the presence of carbon dioxide. Phosphosulfurized hydrocarbons are prepared by reacting

a suitable hydrocarbon such as a terpene, a heavy petroleum fraction of a C<sub>2</sub> to C<sub>6</sub> olefin polymer such as polyisobutylene, with from 5 to 30 wt.% of a sulfide of phosphorus for 1/2 to 15 hours, at a temperature in the range of 65° to 320°F. Neutralization of the phosphosulfurized hydrocarbon may be effected in the manner taught in U.S. Patent No. 1,969,324.

Oxidation inhibitors reduce the tendency of mineral oils to deteriorate in service which deterioration is evidenced by the products of oxidation such as sludge and varnish-like deposits on the metal surfaces. Such oxidation inhibitors include alkaline earth metal salts of alkylphenolthioesters having preferably C<sub>5</sub> to C<sub>12</sub> alkyl side chains, e.g., calcium nonylphenol sulfide, barium t-octylphenyl sulfide, dioctylphenylamine, phenylalphanaphthylamine, phosphosulfurized or sulfurized hydrocarbons, etc.

Representative examples of suitable additional friction modifiers which may be added to the lubricating oil formulations are found in U.S. Patent No. 3,933,659 which discloses fatty acid esters and amides; U.S. Patent No. 4,176,074 which describes molybdenum complexes of polyisobutyryl succinic anhydride-amino alkanols; U.S. Patent No. 4,105,571 which discloses glycerol esters of dimerized fatty acids; U.S. Patent No. 3,779,928 which discloses alkane phosphonic acid salts; U. S. Patent No. 3,778,375 which discloses reaction products of a phosphonate with an oleamide; U. S. Patent No. 3,852,205 which discloses S-carboxyalkylene hydrocarbyl succinimide, S-carboxyalkylene hydrocarbyl succinamic acid and mixtures thereof; U. S. Patent No. 3,879,306 which discloses N-(hydroxyalkyl)alkenyl-succinamic acids or succinimides; U. S. Patent No. 3,932,290 which discloses reaction products of di-(lower alkyl) phosphites and epoxides; and U. S. Patent No. 4,028,258 which discloses the alkylene oxide adduct of phosphosulfurized N-(hydroxyalkyl) alkenyl

succinimides. The disclosures of the above references are herein incorporated by reference. The most preferred friction modifiers to be used in combination with the blend of amide/amine and ester/alcohol friction modifier of the present invention are succinate esters, or metal salts thereof, of hydrocarbyl substituted succinic acids or anhydrides and thiobis alkanols such as described in U. S. Patent No. 4,344,853, disclosure of this patent also being herein incorporated by reference.

Dispersants maintain oil insolubles, resulting from oxidation during use, in suspension in the fluid thus preventing sludge flocculation and precipitation or deposition on metal parts. Suitable dispersants include high molecular weight polyalkenyl succinimides, e.g., the reaction product of oil-soluble polyisobutylene succinic anhydride with ethylene amines such as tetraethylene pentamine and borated salts thereof.

Pour point depressants lower the temperature at which the fluid will flow or can be poured. Such depressants are well known. Typically of those additives which usefully optimize the low temperature fluidity of the fluid are C<sub>8</sub>-C<sub>18</sub> dialkylfumarate vinyl acetate copolymers, polymethacrylates, and wax naphthalene. Foam control can be provided by an antifoamant of the polysiloxane type, e.g., silicone oil and polydimethyl siloxane.

Anti-wear agents, as their name implies, reduce wear of metal parts. Representatives of conventional anti-wear agents are zinc dialkyldithiophosphate, zinc diaryldithiophosphate and magnesium sulfonate.

Some of these numerous additives can provide a multiplicity of effects, e.g., a dispersant-oxidation inhibitor. This approach is well known and need not be further elaborated herein.

Compositions when containing these conventional additives are typically blended into the base oil in amounts which are effective to provide their normal

attendant function. Representative effective amounts of such additives are illustrated as follows:

<u>Additive</u>	<u>Vol %</u>	<u>Wt %</u>
Viscosity Modifier	0.01	1-4
Corrosion Inhibitor	0.01-1	0.01-1.5
Oxidation inhibitor	0.01-1	0.01-1.5
Dispersant	0.1 -7	0.1 -8
Pour Point Dispersant	0.01-1	0.01-1.5
Detergents/Rust Inhibitors	0.01-2.5	0.01-3
Anti-Foaming Agents	0.001-0.1	0.001-0.15
Anti-Wear Agents	0.001-1	0.001-1.5
Friction Modifiers	0.01-3	0.01 -1.5
Lubricating Base Oil	Balance	Balance

When other additives are employed, it may be desirable, although not necessary, to prepare additive concentrates comprising concentrated solutions or dispersions of the friction modifier blend (in concentrate amounts hereinabove described), together with one or more of said other additives (said concentrate when constituting an additive mixture being referred to herein as an additive-package) whereby several additives can be added simultaneously to the base oil to form the lubricating oil composition. Dissolution of the additive concentrate into the lubricating oil may be facilitated by solvents and by mixing accompanied with mild heating, but this is not essential. The concentrate or additive-package will typically be formulated to contain the blend of friction modifier additives and optional additional additives in proper amounts to provide the desired concentration in the final formulation when the additive-package is combined with a predetermined amount of base lubricant. Thus, the blend of friction modifier additives of the present invention can be added to small amounts of base oil or other compatible solvents along with other desirable additives to form

**SUBSTITUTE SHEET**

additive-packages containing active ingredients in collective amounts of typically from about 2.5 to about 90%, and preferably from about 5 to about 75%, and most preferably from about 8 to about 50% by weight additives in the appropriate proportions with the remainder being base oil.

The final formulations may employ typically about 10 wt.% of the additive-package with the remainder being base oil.

All of said weight percents expressed herein are based on active ingredient (A.I.) content of the additive, and/or upon the total weight of any additive-package, or formulation which will be the sum of the A.I. weight of each additive plus the weight of total oil or diluent.

This invention will be further understood by reference to the following examples, wherein all parts are parts by weight and all molecular weights are number average molecular weights unless otherwise noted, and which include preferred embodiments of the invention.

**EXAMPLE 1** (Preparation of amine/amide friction modifier)

Approximately 847 grams (3 moles) of oleic acid and 189 grams (1 mole) of tetraethylene pentamines (TEPA) were charged to a reaction flask. The mixture was then heated under an inert (N<sub>2</sub>) atmosphere to about 190°C, removing water by distillation. After about 20 hours, the reaction appeared to be complete, and the reaction mixture was cooled and filtered. The reaction product comprised an oleic acid-TEPA friction modifying agent and was found to have a total acid number (TAN) of about 6.0.

Samples of a lubricating oil formulation containing a friction modifier blend prepared in accordance with this invention were subjected to a

standard ball-on cylinder test. Similar samples formulations containing either no friction modifier or friction modifiers outside the scope of this invention were also tested.

The ball-on cylinder (BOC) test, which forecasts the friction performance of a given oil formulation, is described in : W.E. Waddey, H. Shaub, J.M. Pecorard, and R.A. Carley, "Improved Fuel Economy Via Engine Oils", SAE Paper no. 780,599 (1978).

This test examines steel-steel boundary lubrication in terms of friction coefficient. It has been applied as a 'first stage' screening tool for fuel-efficient engine oil (FEED) selection. The BOC conditions are believed to represent 'pure' boundary-friction (BL). It's use in screening FEED's is described in: TF Lonstrup, H.E. Bacheran, and C.R. Smith, "Testing the Fuel Economy Characteristics of Engine Oils," SAE Paper no. 790,949 (1979).

The BOC device consists basically of a rotating chrome steel cylinder to which is held a stationary steel ball at a fixed normal load. The cylinder is partly immersed in the test oil which distributes over the surface of the cylinder. The restraining force on the steel ball is measured by a linear variable differential transformer (LVDT) and recorded on a strip-chart. The cylinder wear tracks's cross-section is later examined with a surface profilometer.

BOC test conditions/parameters:

- AISI 52100 alloy steel ball of Rockwell hardness of 62-64
- AISI 52100 alloy steel cylinder of Rockwell hardness of 20
- turning speed of cylinder-approximately 0.26
- wet air is bubbled into the lubricant reservoir
- applied load on cylinder - 4 kg

**SUBSTITUTE SHEET**

- lubricant temperature-120°C.
- test time-50 minutes

1 = boundary friction coefficient:  $u = \frac{\text{drag force}}{\text{normal load}}$  BL does not depend on bulk lubricant viscosity; instead BL is controlled by chemical properties of the lubricant and the metal's surface (beilby layer)

The base oil formulation used in the ball-on cylinder tests was an SG/Tier 1 10W30 crankcase lubricating oil formulation containing only a refined base mineral oil, a dispersant, viscosity index improver, a pour point depressant and a zinc dialkyldithiophosphate anti-wear additive. To this base formulation, there was added either no friction modifier (control), 0.1 wt. % of Loxiol G11 (a glycerine monoricinoleate friction modifier marketed by Henkel Corporation; Comparative Formulation 1), 0.2 wt.% of a glycerine mono- and dioleate friction modifier (Comparative Formulation 2), 0.2 wt. % of the oleic acid/TEPA friction modifier of EXAMPLE 1 (Comparative Formulation 3), a blend of 0.2 wt.% of glycerine mono- and dioleate and 0.2 wt.% of the oleic acid/TEPA of EXAMPLE 1 (Formulation 4), a blend of 0.1 wt.% of Loxiol G11, 0.2 Wt.% glycerine mono- and dioleate and 0.2 wt. % of oleic acid/TEPA (Formulation 5), a blend of 0.1 wt.% Loxiol G11 and 0.2 wt. % of oleic acid/TEPA (Formulation 6), or a blend of 0.1 wt. % Loxiol G11 and 0.2 wt.% glycerine mono- and dioleate (Comparison Formulation 7).

The ball-on cylinder test was conducted at 120°C for a duration of 50 minutes and the results for each formulation was observed. At the initial stage of the tests (8-16 minutes) only Comparative Formulation 3 and Formulations 4, 5 and 6 showed significant effect in

SUBSTITUTE SHEET



friction reduction. At the second stage (16-32 minutes) Comparative Formulation 1 also showed strong friction reducing effect, in addition to formulations 4, 5 and 6. The overall test duration indicated a significant synergistic effect on friction reduction with Loxiol G11 and oleic acid/TEPA (Formulation 6), with the greatest reduction in friction being observed with the system containing the three friction modifiers Loxiol G11, glycerine mono- and dioleate, and oleic acid/TEPA (Formulation 5).

Based on the above results, a standard ASTM Sequence VI test was run for comparative Formulation 1, for Comparative Formulation 7, and for Formulation 5.

The Sequence VI test procedure (SAE JI 423 May 1988) is used for evaluating engine oils and for identifying energy conserving engine oils for passenger cars, vans, and light duty (8500 lbs GVW or less) trucks. The recommended practice (JI 423) involves a classification for engine oils that have energy-conserving characteristics under certain operating conditions and are categorized as "Energy Conserving" (tier I) or "Energy Conserving II" (tier II). In accordance with the definitions set forth in the Sequence VI test procedure (SAE JI 423 May 1988), Energy Conserving (tier I) and Energy Conserving II (tier II) engine oils are lubricants that demonstrate reduced fuel consumption when compared to specified ASTM reference oils using a procedure which is described in ASTM Research Report No. RR:PDO2:1204, "Fuel Efficient Engine Oil Dynamometer Test Development Activities, Final Report, Part II, August 1985."

The Sequence VI procedure compares fuel consumption with a candidate oil to that with the ASTM HR (High Reference) SAE 20W-30 Newtonian oil in terms of Equivalent Fuel Economy Improvement (EFEI) by use of the following equation:

**SUBSTITUTE SHEET**

$$\text{EFEI} = \frac{[0.65 (\text{Stage 150}) + 0.35 (\text{Stage 275}) - 0.61}{1.38}$$

The equation is used to transfer the data obtained in two stages of an older procedure, known as the five-car procedure (published as D-2 Proposal P101 in Volume 05.03 of the 1986 ASTM Book of Standards), which is an alternative method only for use in evaluating engine oils that meet the Energy Conserving (tier I) category.

To fulfill the Tier I energy-conserving requirement using the five-car procedure, the candidate oil must meet the performance limits of the classification published as a proposal in Volume 05.03 of the ASTM Book of Standards (D-2 Proposal P102) and shown graphically in Fig. 1 herein. The five-car average fuel consumption with the candidate oil must be less than that with reference oil HR by at least 1% and the minimum lower 95% confidence level (LCL95) must be at least 0.3%. When using reference oil HR-2, the average fuel consumption with the candidate oil must be at least 1.5% less than that with reference oil with a minimum LCL95.

When the Sequence VI test is used, the results obtained in two of the stages of the test are transformed to an equivalent five-car percent improvement by use of the above equation.

The Equivalent Fuel Economy improvement (EFEI) from the Sequence VI test must meet the limits of the aforementioned classification D-2 Proposal P102, with the exception of the LCL95 requirement which applies to only the five-car procedure. For a candidate oil to be categorized as Energy Conserving II the Equivalent Fuel Economy Improvement (EFEI) as described above and as shown graphically in Fig. 1, must be a minimum of 2.7% when compared to HR-2.

Thus Engine oils categorized as "Energy Conserving, (tier I) are formulated to improve the fuel

economy of passenger cars, vans and light-duty trucks by an EFEI of 1.5% or greater over a standard reference oil in a standard test procedure, whereas oils categorized as "Energy Conserving II" (tier II) are formulated to improve the fuel economy of passenger cars, vans and light-duty trucks by an EFEI of 2.7% or greater over a standard reference oil in a standard test procedures. Of course, the actual fuel economy obtained by individual vehicle operators using engine oils which are labeled "ENERGY CONSERVING" or "ENERGY CONSERVING II" may differ because of many factors including type of vehicle and engine, engine manufacturing variables, mechanical condition and maintenance of the engine, oil previously used, operating conditions, and driving habits.

The Sequence VI test resulted in an EFEI % of 2.47 for Comparative Formulation 1, an EFEI % of 2.65 for Comparative Formulation 7, and an EFEI % of 2.86 for Formulation 5. Thus, it can be seen that blends of friction modifiers in accordance with the present invention can be used to achieve tier II fuel economy, i.e. an EFEI % of at least about 2.7.

As will be evident to those skilled in the art, various modifications of the invention can be made or followed, in light of the forgoing disclosure and illustrative examples, tables and discussion, without departing from the scope of the disclosure or from the scope of the invention as set forth in the following claims.

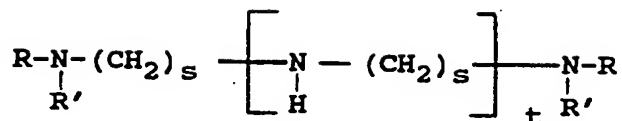
## CLAIMS:

1. A blend of friction modifier additives comprising at least one amine/amide friction modifier and at least one ester/alcohol friction modifier, said blend having a weight ratio of amine/amide: ester/alcohol of from 1:10 to about 10:1, said amide/amine friction modifier having been prepared by reacting at least one least linear or branched, saturated or unsaturated aliphatic carboxylic acid having from about 6 to about 36 total carbon atoms with at least one polyamine having from about 2 to about 20 nitrogen atoms, and said ester/alcohol friction modifier having been prepared by reacting at least one linear or branched, saturated or unsaturated aliphatic carboxylic acid having from about 6 to about 36 total carbon atoms with at least one polyhydric alcohol.

2. The blend of friction modifiers according to claim 1, wherein each of said amide/amine friction modifier and said ester/alcohol friction modifier are prepared from at least one acid containing from about 7 to about 24 total carbon atoms.

3. The blend of friction modifiers according to claim 2, wherein each of said amine/amide friction modifier and said ester/alcohol friction modifier are prepared from an acid selected from the group consisting of isostearic acid, oleic acid, linoleic acid, ricinoleic acid and mixtures thereof.

4. The blend of friction modifiers according to claim 1, wherein said polyamine comprises an aliphatic saturated amine having the formula



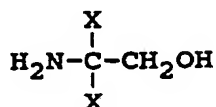
wherein R and R' independently are selected from the group consisting of hydrogen, C<sub>1</sub> to C<sub>25</sub> straight or branched chain alkyl radicals, C<sub>1</sub> to C<sub>12</sub> alkoxy C<sub>2</sub> to C<sub>6</sub> alkylene radicals, and C<sub>1</sub> to C<sub>12</sub> alkylamino C<sub>2</sub> to C<sub>6</sub> alkylene radicals, wherein each s is the same or a different number of from 2 to 6, and wherein t is a number of from 0 to 10, with the provision that when t=0, at least one of R or R' must be H such that there are at least two of either primary or secondary amino groups.

5. The blend of friction modifiers according to claim 4, wherein said polyamine is selected from the group consisting of 1, 2-diaminoethane; 1, 3-diaminopropane; 1, 4-diaminobutane; 1, 6-diaminohexane; diethylene triamine; triethylene tetramine; tetraethylene pentamine; 1, 2-propylene diamine; di-(1, 2-propylene)triamine; di-(1, 3-propylene) triamine; N, N-dimethyl-1, 3-diaminopropane; N, N-di-(2-aminoethyl) ethylene diamine; and N-dodecyl-1, 3-propane diamine.

6. The blend of friction modifiers according to claim 1, wherein said polyhydric alcohol is an aliphatic alcohol containing from 3 to 15 carbon atoms and at least 3 hydroxyl groups.

7. The blend of friction modifiers according to claim 6, wherein said polyhydric alcohol is a member selected from the group consisting of glycerol, erythritol, pentaerythritol, mannitol, sorbitol, 1,2,4-hexanetriol, and tetrahydroxy pentane.

8. The blend of friction modifiers according to claim 1, wherein said polyhydric alcohol is a 2,2-disubstituted-2-amino-1-alkanol of the formula



wherein X is alkyl or hydroxyalkyl group with the alkyl groups having from 1 to 3 carbon atoms, wherein at least one of the X substituents is a hydroxyalkyl group of the formula  $(\text{CH}_2)_n\text{OH}$ , and wherein n is 1 to 3.

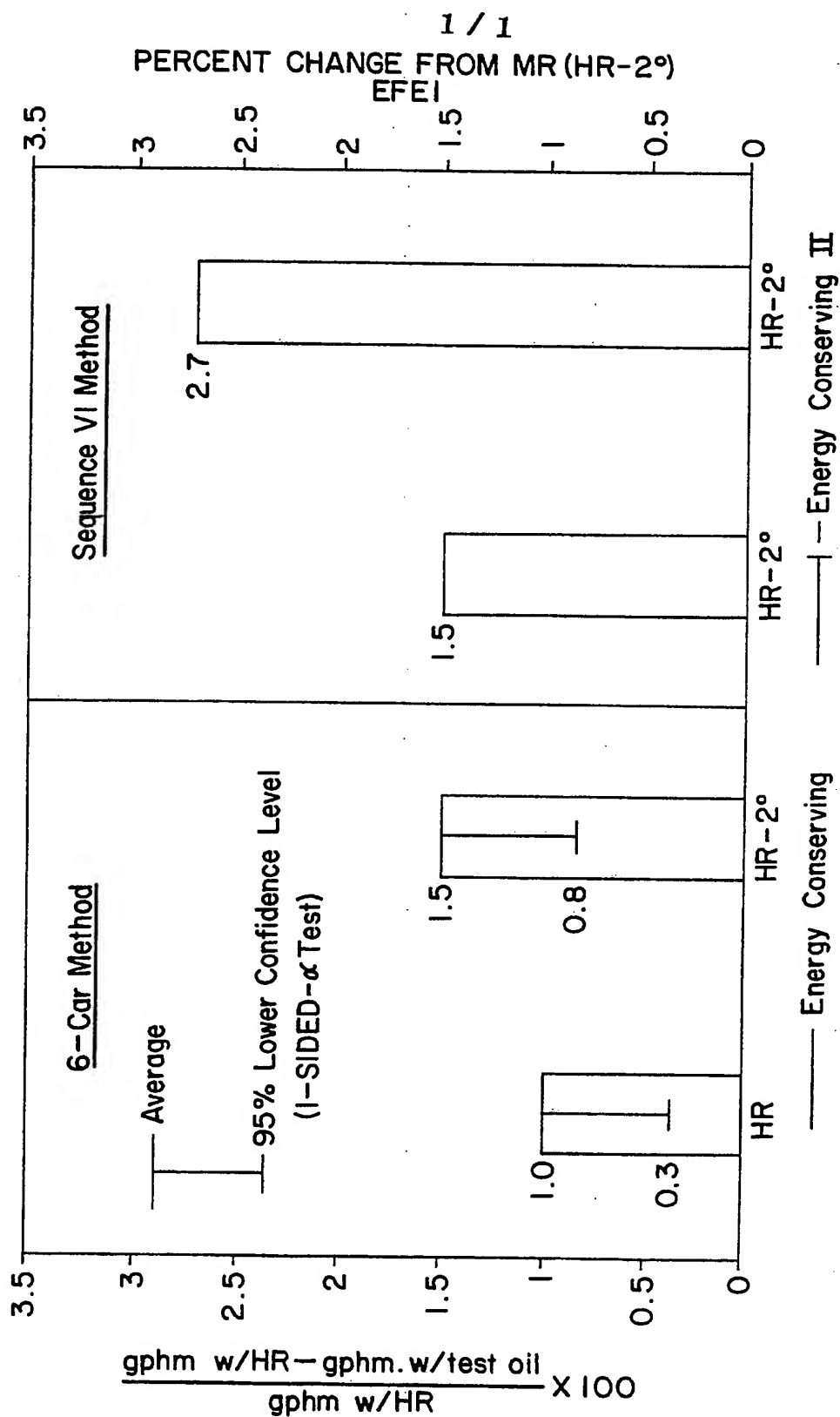
9. The blend of friction modifiers according to claim 8, wherein said amino alcohol comprises tris (hydroxymethyl) amino methane.

10. An oleaginous composition comprising a major amount of an oil of lubricating viscosity, from about 0.01 to about 2 wt. %, based on the total weight of said composition of an amine/amide friction modifier, and from about 0.01 to about 2 wt. % of an ester/alcohol friction modifier, said amide/amine friction modifier having been prepared by reacting at least one least linear or branched, saturated or unsaturated aliphatic carboxylic acid having from about 6 to about 36 total carbon atoms with at least one polyamine having and from about 2 to about 12 nitrogen atoms, and said ester/alcohol friction modifier having been prepared by reacting at least one linear or branched, saturated or unsaturated aliphatic carboxylic acid having form about 6 to about 36 total carbon atoms with at least one polyhydric alcohol.

11. An additive concentrate comprising about 20 to about 80 wt. % lubricating oil and about 20 to about 80% of a blend of an amide/amine friction modifier and an ester/alcohol friction modifier, said blend having a weight ratio of amide/amine:ester/alcohol of from 1:10 to about 10:1, said amide/amine friction modifier having been prepared by reacting at least one linear or branched, saturated or unsaturated aliphatic carboxylic acid having from about 6 to about 36 total carbon atoms with at least one polyamine having from about 2 to about 12 nitrogen atoms, and said ester/alcohol friction modifier having been prepared by reacting at least one linear or branched, saturated or unsaturated aliphatic carboxylic acid having from about 6 to about 36 total carbon atoms with at least one polyhydric alcohol.

12. A process for improving the fuel economy of a vehicle powered by an internal combustion engine having a crankcase, which comprises adding to said crankcase a lubricating motor oil composition according to claim 10.

FIG. 1



SUBSTITUTE SHEET



# INTERNATIONAL SEARCH REPORT

International Application No **PCT/US 91/05392**

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl.5      C 10 M 133/02      C 10 M 141/06      //(C 10 M 141/06 C 10 M 129:76      C 10 M 133:16 )      (C 10 M 133/02      C 10 M 133:08 C 10 M 133:16)      C 10 N 30:06      C 10 N 40:25		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl.5	C 10 M	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	EP,A,0305538 (IDEMITSU KOSAN CO. LTD) 8 March 1989, see the whole document	1-7, 10, 11
Y	---	8, 9, 12
Y	FR,A,1390948 (SHELL) 25 January 1965, see the whole document	8, 9
Y	---	12
A	GB,A,2034748 (ETHYL) 11 June 1980, see the whole document	8, 9
Y	---	12
Y	FR,A,2444706 (CHEVRON) 18 July 1980, see the whole document	12
Y	GB,A,2097813 (EXXON) 10 November 1982, see the whole document	12
	---	
	-/-	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
23-10-1991	09. 12. 91	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 Nuria TORIBIO	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	----	1-11
X	EP,A,0335701 (ETHYL) 4 October 1989, see claims; page 4	1-7,10, 11
Y		12
A		8,9
Y	GB,A,2034747 (ETHYL) 11 June 1980, see the whole document -----	12

# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

US 9105392  
SA 50336

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/11/91. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0305538	08-03-89	WO-A- 8806616	07-09-88
FR-A- 1390948		BE-A- 637871	
		DE-A, C 1444904	27-02-69
		GB-A- 984409	
		NL-C- 131916	
		NL-A- 283779	
GB-A- 2034748	11-06-80	US-A- 4208293	17-06-80
		BE-A- 879884	07-05-80
		CA-A- 1136608	30-11-82
		DE-A, C 2945850	14-05-80
		FR-A, B 2440986	06-06-80
		JP-C- 1354026	24-12-86
		JP-A- 55066996	20-05-80
		JP-B- 61021517	27-05-86
		US-A- 4439336	27-03-84
FR-A- 2444706	18-07-80	CA-A- 1157846	29-11-83
		DE-A- 2949910	03-07-80
		GB-A, B 2038356	23-07-80
		JP-A- 55084394	25-06-80
GB-A- 2097813	10-11-82	AU-B- 554024	07-08-86
		AU-A- 8340582	11-11-82
		BE-A- 893083	05-11-82
		CA-A- 1174660	18-09-84
		DE-A- 3216390	13-01-83
		FR-A, B 2505355	12-11-82
		JP-A- 57187394	18-11-82
		NL-A- 8201866	01-12-82
		US-A- 4683069	28-07-87
EP-A- 0335701	04-10-89	US-A- 4960530	02-10-90
		US-A- 5028345	02-07-91
		EP-A- 0335702	04-10-89
		JP-A- 1299892	04-12-89
		JP-A- 1304185	07-12-89
		US-A- 4960528	02-10-90

EPO FORM P007

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**US 9105392  
SA 50336

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/11/91  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2034747	11-06-80	US-A- 4201684	06-05-80
		BE-A- 879863	06-05-80
		CA-A- 1133885	19-10-82
		DE-A, C 2945851	14-05-80
		FR-A, B 2440987	06-06-80
		JP-C- 1289196	14-11-85
		JP-A- 55102693	06-08-80
		JP-B- 60011997	29-03-85
-----			

EPO FORM P0079

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82